## What is claimed is:

1. A method for performing packet combined scheduling of dedicated transport channels for packet services in UMTS downlinks, wherein dedicated traffic channels (DTCHs) in logical channels are mapped as dedicated channels (DCHs) in transport channels, and N DCHs, in their respective input queues, queue up for being transported to the corresponding M DPCHs, where $M \leq N$, the method being characterized in that the method for performing packet combined scheduling of the DCHs comprises the following steps:

a) prior to each DCH scheduling period, performing pre-selection processing of a transport format combination of each DPCH according to the predetermined restriction conditions for the DCH combined packet scheduling, so as to determine a usable transport format combination set $\mathrm{TFCS}_m^{(2)}$ for each DPCH;

b) restricting a total downlink transmit power $\sum_{n=1}^{N} P_{k,n}$ of DCHs for NRT packet services to a schedulable power not exceeding a schedulable power in the estimation of a total downlink power during said scheduling period, i.e., the maximum allowable power value $P_k^{Scheduled}$, where $P_{k,n}$ denotes an average transmit power required by the N-th DCH in the k-th scheduling period, and $P_k^{Scheduled}$ denotes the maximum allowable power allocated to the DCHs which bear NRT packet services in the estimation of downlink power in the k-th scheduling period;

c) based on the fairness of DCH transportation and the QoS requirements of the DCH-borne services, determining weighted values which the respective DCHs correspond to in the optimization of the DCH

combined packet scheduling; and

d) based on the results of steps a), b), and c), calculating the maximum number of bit(s) which each DCH is schedulable to output, using a 0-1 programming algorithm.

2. The method as defined in claim 1, characterized in that said determining the usable transport format combination set $\mathrm{TFCS}_m^{(2)}$ for each DPCH according to the predetermined restriction conditions for the DCH combined packet scheduling in step a) further comprises:

placing a high-priority packet at the front of an input buffer queue of a corresponding DCH; and

performing the pre-selection processing on TFCS based on the TFCS of the DPCH, the activated DCH, and the length of the input queue of the DCH, thereby obtaining the usable $\mathrm{TFCS}_m^{(2)}$ of each DPCH in the current scheduling period.

3. The method as defined in claim 2, characterized in that the pre-selection processing further comprises the steps of:

i ) selecting a TFC set $\mathrm{TFCS}_m^{(0)} = \{(\mathrm{TF}_1, \mathrm{TF}_2, \cdots, \mathrm{TF}_{S_m})\}_m^{(0)}$ in which the size and number of transport blocks which each DCH is scheduled to output meet the limit of the TFCS which the DCH corresponds to, where $m = 1,2,\cdots M$, $S_m$ representing the dimension of the TFC of the m-th DPCH, that is, $S\,(m)$ DCHs are multiplexed on the m-th DPCH;

ii ) determining whether each DCH in each DPCH has been activated in the current scheduling period; if a certain DCH has been activated, then removing all the transport formats combinations excluding the transport format being currently used by the DCH from the usable TFC

set obtained by step (i) of the DPCH which the DCH corresponds to, the usable TFC set of each DPCH obtained by step ii) being marked as $\mathrm{TFCS}_m^{(1)} = \{(\mathrm{TF}_1, \mathrm{TF}_2, \cdots, \mathrm{TF}_{S_m})\}_m^{(1)}$, where $m = 1,2,\cdots M$; and

iii ) removing all transport formats combinations which satisfy the following conditions from the usable TFC set of each DPCH obtained by step (ii): the TFC contains at least one transport format indicating that the number of the bit(s) transportable on the corresponding DCH within the current scheduling period is greater than the length of the current input buffer queue of the corresponding DCH, the usable TFC set of each DPCH obtained by step (iii) being marked as $\mathrm{TFCS}_m^{(2)} = \{(\mathrm{TF}_1, \mathrm{TF}_2, \cdots, \mathrm{TF}_{S_m})\}_m^{(2)}$, where $m = 1,2,\cdots M$.

4. The method as defined in claim 2, characterized in that the high-priority packet is a status Protocol Data Unit packet of a Radio Link Control layer of an Acknowledged Mode.

5. The method as defined in claim 1, 2 or 3, characterized in that said method further comprises, prior to the pre-selection processing in step a), a step of performing DTCH scheduling allocation for the DCH by using the Round-Robin, WFQ or $\mathrm{WF}^2\mathrm{Q}$ scheduling algorithm.

6. The method as defined in claim 1, characterized in that the step b) further comprises:

calculating a predicted/estimated value $\hat{c}_{k,n}$ of the proportional coefficient of the average transmit power $P_{k,n}$ of the n-th DCH and the number of the bit(s) $R_{k,n}$ of the n-th DCH scheduled to be output in the k-th scheduling period.

7. The method as defined in claim 6, characterized in that the proportional coefficient $\hat{c}_{k,n}$ in the current scheduling period is predicted/estimated by using a linear prediction filter based on the following equation:

$$\hat{c}_{k,n} = (1-\alpha)\cdot\hat{c}_{k-1,n} + \alpha\cdot c_{k-1,n},$$

where $\alpha$ is a filter coefficient and $\alpha\in[0,1]$; $c_{k-1,n}$ is a ratio of a measurement value of an actual transmit power of the n-th DCH and the number of the bit(s) actually scheduled to be output in the (k-l)-th scheduling period.

8. The method as defined in claim 1, characterized in that step c) further comprises a step of determining the corresponding weighted values of respective DCHs in the DCH combined packet scheduling optimization based on a product of a dynamic weighted value $w_{k,n}^{Fair}$ and a static weighted value $w_n^{QoS}$, wherein

the static weighted value $w_n^{QoS}$ is determined based on the priorities of services borne by the n-th DCH;

an average scheduling index $\overline{\eta}_{k,n}$ of the n-th DCH in the k-th scheduling period is calculated based on the recorded scheduling result of each DCH, and the dynamic weight value $w_{k,n}^{Fair}$ is determined based on the following formula:

$$w_{k,n}^{Fair} = 1-\overline{\eta}_{k,n}; \quad \text{or} \quad w_{k,n}^{Fair} = \frac{1}{\overline{\eta}_{k,n}}.$$

9. The method as defined in claim 8, characterized in that the average

scheduling index $\overline{\eta}_{k,n}$ is determined by one of the following methods:

i ) smoothing filtering the scheduling index of the n-th DCH in the past (k-l)-th scheduling period: $\overline{\eta}_{k,n}=\frac{1}{L}\sum_{l=1}^{L}\eta_{k-l,n}$, wherein L represents the number of the past scheduling periods participating in the smoothing filtering;

ii ) adjusting the formula in method i ) : $\overline{\eta}_{k,n}=\frac{1}{L}\sum_{l=1}^{L}\lambda^{l-1}\eta_{k-l,n}$, where factor $\lambda$ is $\lambda\in(0,1]$; or

iii ) performing the smoothing filtering by using a first-order Infinite Impulse Response filter: $\overline{\eta}_{k,n}=(1-\beta)\cdot\overline{\eta}_{k-1,n}+\beta\cdot\eta_{k-1,n}$, where filter coefficient $\beta$ is $\beta\in[0,1]$.

10. The method as defined in claim 9, characterized in that the "scheduling index" of the n-th DCH in the (k-l)-th scheduling period is defined as:

$$\eta_{k-l,n}=\begin{cases}\dfrac{R_{k-l,n}}{\max\{R_{k-l,n}\}} & \max\{R_{k-l,n}\}\neq 0\\ 1 & \max\{R_{k-l,n}\}=0\end{cases}.$$

where, $R_{k-l,n}$ represents the number of the bit(s) which the n-th DCH is scheduled to output in the (*k-l*)-th scheduling period, and $\max\{R_{k-l,n}\}$ represents the maximum value in a discrete limited area of the schedulable bits which the n-th DCH corresponds to in the (*k-l*)-th scheduling period.

11. The method as defined in claim 1, characterized in that step d) further comprises:

converting the maximization of a target function in the DCH

combined packet scheduling into 0-1 programming minimizing the target function by using the calculating results in steps a), b) and c), then further converting the 0-1 programming into a linear programming for processing, thereby calculating the number of the bit(s) which each DCH is scheduled to output, wherein

the target function in the DCH combined packet scheduling is defined as:

$J=\sum_{n=1}^{N} w_n R_n$, where $R_n$ should satisfy the restriction condition: $\sum_{n=1}^{N} \hat{c}_n R_n \le P^{Scheduled}$, and $R_n \in \Psi_n$, wherein $\Psi_n$ is a discrete limited area;

the target function minimized by the 0-1 programming and converted from the target function in the DCH combined packet scheduling is defined as:

$$J=\sum_{m=1}^{M}\sum_{i=1}^{D_m}\left(W_{m,i}\cdot q_{m,i}\right),$$

the restriction condition being

$$\begin{cases} S+\sum_{m=1}^{M}\sum_{i=1}^{D_m}\left(C_{m,i}\cdot q_{m,i}\right)=P^{Scheduled}, \quad S\ge 0 \\ \sum_{i=1}^{D_m} q_{m,i}=1, \quad q_{m,i}\in\{0,1\}, \quad m=1,2,\cdots M \end{cases}$$

where, S is a slack variable, and parameters $W_{m,i}$ and $C_{m,i}$ in the above 0-1 programming are given in the following formulas:

$$W_{m,i}=-\sum_{j=1}^{S_m}\left[w_{m,j}\cdot r_{m,j}(i)\right]$$

$$C_{m,i}=\sum_{j=1}^{S_m}\left[\hat{c}_{m,j}\cdot r_{m,j}(i)\right],$$

and based on formula $R_{m,j}=\sum_{i=1}^{D_m}\left[q_{m,i}\cdot r_{m,j}(i)\right]$, calculating the number of the bit(s) $R_{m,j}$ which each DCH is optimally scheduled to output, wherein:

$q_{m,i}$ represents a 0-1 indicator variable and $q_{m,i} \in \{0,1\}$, $i = 1,2,\cdots,D_m$; $D_m$ is the number of elements of the usable TFC set $\mathrm{TFCS}_m^{(2)}$ of DPCH$_m$; $q_{m,i}$ corresponds to each element in said TFC set, respectively; DCHs multiplexed to the same DPCH are regarded as a group, so $M$ DPCHs have $M$ groups of DCHs, each group containing $S_m (m = 1,2,\cdots M)$ DCHs, the DCHs being numbered as $\mathrm{DCH}_{m,1}, \mathrm{DCH}_{m,2}, \cdots, \mathrm{DCH}_{m,S_m}$ based on their turns in the TFC of the corresponding DPCH$_m$, *and* $R_n$, $w_n$, $\hat{c}_n$ are also correspondingly marked as $R_{m,j}$, $w_{m,j}$, $\hat{c}_{m,j}$, where $j = 1,2,\cdots,S_m$, $r_{m,j}(i)$ being the number of transmissible bit(s) in the current scheduling period indicated by the transport format of the j-th DCH contained in the i-th TFC in the $\mathrm{TFCS}_m^{(2)}$.

12. The method as defined in claim 1, characterized in that steps a), b) and c) are executed in a parallel way.

13. The method as defined in claim 1, characterized in that the scheduling period is the frame length of a physical channel.

14. AN apparatus for performing packet combined scheduling of dedicated transport channels for packet services in UMTS downlinks, wherein dedicated traffic channels (DTCHs) in the logical channels are mapped as dedicated channels (DCHs) in the transport channels, and N DCHs, in their respective input queues, queue up for being transported to the corresponding M DPCHs, where $M \le N$; the apparatus being characterized in that the apparatus for performing the packet combined scheduling of the DCHs comprises:

a pre-selection processing unit for, prior to each DCH scheduling

period, performing pre-selection processing of a transport format combination of each DPCH according to the predetermined restriction conditions for the DCH combined packet scheduling, so as to determine a usable transport format combination set $\mathrm{TFCS}_m^{(2)}$ for each DPCH;

a power restriction proportional coefficient calculating unit for calculating a predicted/estimated value $\widehat{c}_{k,n}$ of a proportional coefficient of an average transmit power $P_{k,n}$ of the n-th DCH within the k-th scheduling period and the number of bit(s) $R_{k,n}$ which the DCH is schedulable to output within the scheduling period;

a target function weighted value calculating unit for, based on fairness of DCH transportation and QoS requirements of the DCH-borne services, calculating corresponding weighted values of respective DCHs in optimization of the DCH combined packet scheduling; and

a 0-1 programming-based optimum packet scheduling calculating unit for, based on output results of the pre-selection processing unit, the power calculating unit and the target function weighted value calculating unit, calculating the maximum number of the bit(s) which each corresponding DCH is schedulable to output, by using a linear programming algorithm.

15. The apparatus as defined in claim 14, characterized in that the pre-selection processing unit further comprises:

a DTCH scheduling module for executing a DTCH scheduled allocation of the DCH by using Round-Robin, WFQ or $\mathrm{WF}^2\mathrm{Q}$ scheduling algorithm;

a priority queuing module for putting a high-priority packets, such

as a status PDU of a RLC of the AM, at the front of the input buffer queue of the corresponding DCH;

a TFCS pre-selection processing module for conducting the pre-selection processing on TFCS based on the TFCS of the DPCH, the activated DCH, and the length of the input queue of the DCH, thereby to obtain the usable $TFCS_m^{(2)}$ of each DPCH in the current scheduling period.

16. The method as defined in claim 14, characterized in that said power calculating unit further comprises:

a linear prediction filter for estimating a power restriction proportional coefficient of each DCH in the current scheduling period based on a ratio of a measurement value of each DCH's actual transmit power to the recorded actual number of the bit(s) scheduled to be output in the previous scheduling period.

17. The apparatus as defined in claim 14, characterized in that said target function weighted value calculating unit further comprises:

a dynamic weighted value calculating module for calculating the dynamic weighted value in the target function according to the recorded scheduling result of each DCH based on the fairness requirement of each DCH;

a static weighted value calculating module for determining the static weighted value based on the priorities of services borne by each DCH; and

a multiplier for multiplying the dynamic weighted value and the static weighted value of each DCH thereby to obtain the weighted value

of the target function.

18. The apparatus as defined in claim 14, characterized in that said 0-1 programming-based optimum packet scheduling calculating unit further comprises:

a 0-1 programming parameter calculating module for converting, based on the output results of the pre-selection processing unit, the power restriction proportional coefficient calculating unit and the target function weighted value calculating unit, the maximization of a target function in the DCH combined packet scheduling into 0-1 programming minimizing the target function and calculating parameters $W_{m,i}$ and $C_{m,i}$ in the 0-1 programming problem;

a linear programming calculating module for calculating the optimum solution vector of indicator variables in the 0-1 programming problem of downlink DCH combined packet scheduling by utilizing the parameters $W_{m,i}$, $C_{m,i}$ and the schedulable power estimation in the current scheduling period, wherein the schedulable power estimation in the current scheduling period is provided by a downlink power allocating unit of a cell radio resource management module; and

a DCH scheduled output bit calculating module for calculating the number of the bit(s) each DCH scheduled to be output in the current scheduling period based on the optimum solution vector of the indicator variables output by the linear programming calculating module.

19. The apparatus as defined in claim 14, characterized in that said pre-selection processing unit, said power calculating unit, and said target function weighted value calculating unit are operated in a parallel way.

20. The apparatus as defined in claim 14, characterized in that the scheduling period of the apparatus is the frame length of a physical channel.



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